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**Keywords**
WASH, water, sanitation, hygiene, Guatemala

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**Introduction**

While there are many peer-reviewed studies examining the relationship between education and health status, only a few studies examine the specific effect of public health education on community health. Many studies veer away from declaring a direct link between education and health, looking instead towards more defined causal pathways – often citing socioeconomic status as the critical intermediary. It is possible that education is often only a proxy for stronger contributing factors towards health, such as family income, access to healthcare, or general behaviors towards health (Chandola et al. 2006; Frost, Forste and Haas 2005). This is likely the reason why so many subsequent studies have questioned and refuted this link. But even according to these studies which denied a direct causal link, many closely-associated indirect measures were found to lead to increased health status. For example, Frost et al. (2005) found that "[b]eginning with the work of Caldwell (1979), a considerable body of research suggests that maternal education is the single most important factor in explaining differentials in child health outcomes, more important than paternal education, health service availability, and socioeconomic status."

A study undertaken in Nicaragua provided a unique opportunity to study education while controlling for socioeconomic status due to a government education initiative that offered free classes to women (Sandiford et al. 1995). Unsurprisingly, it was found that the literate women were both better-off and had lower child malnourishment and mortality rates than illiterate women. Even when controlling for factors such as household income, access to health services, and water supply and sanitation, the relationship between maternal literacy and child health proved significant. In contrast to studies which declare education as merely a proxy for greater contributing factors, Sandiford et al. (1995) claimed that "results from this investigation strongly support the contention that education plays a critical role in child health and survival, independently of other social and economic advantages."

The Nicaragua study is noteworthy due to its ability, to some degree, to effectively separate socioeconomic status from health outcomes – two variables which are usually inseparable. While the causal pathways are disputed, there is a consensus that education is, in some way, connected to better health outcomes.

**Project Background**

Under the guidance of the University of Virginia-Guatemala Initiative (UVa-GI) and funded by a Jefferson Public Citizens grant, students in the graduate public health program spent three years (2010-2013) working on a health education and clean water program in one of San Lucas Tolimán's rural communities. The program consisted of an 18-week education course culminating in the distribution of a HydrAid bio-sand filter to each participant.

In the summer of 2011, a quantitative and qualitative review of water access, resources, and perceptions in the San Lucas Tolimán urban center, as well as three of its rural communities, was performed. Working in close collaboration with community partners, in-depth interviews were performed with community leaders, door-to-door surveys, water testing, and visual surveying. The results were then used to devise effective and sustainable ways to address the community-identified issues in an appropriate manner. San Martin was the only community to specifically request health education as well as in-home purification systems. Additionally, it was the largest of the three rural communities, the only one to receive its water directly from the lake (via miles of old tubing), and had the most reliable infrastructure, with a central paved road.

The program in San Martin was based on a similar pilot program started by UVa-GI about four years earlier in Tzunana, another rural community along the shores of Lake Atitlán. The curriculum was divided into three courses: hygiene and sanitation, nutrition, and filter use and maintenance. It was taught by a local woman, hired and trained by UVa-GI. Based on a review of the pilot in Tzunana, a priority was to revise the new program to make it as interactive as possible, adding at least one game or activity to every class. Examples of such activities include interactive demonstrations by the teacher of how contamination occurs, matching games, creating personal nutrition ollas (pots) (the Guatemalan version of the "food pyramid"), and assembling paper filters from cut-outs of their individual parts.

A local woman with both nursing and community outreach experience, who spoke the local indigenous language, was hired and trained as the instructor. This allowed for the class to be taught bilingually in Spanish and Kaqchikel. The study then recruited twenty women to participate in the class. In exchange for regular attendance and participation, they received an in-home biosand filter which would be installed during the final unit of classes. Each class was approximately one hour per week. Additionally, between classes during the week the teacher returned to San Martin to perform personal in-home visits during which she would check-in with each woman about what was learned in the previous lesson.

[1] A. Maddox, University of Virginia, Master of Public Health Program, April 2013

**Family Profiles**

All women from the first round of classes were of Mayan descent. None had more than a primary education and literacy rates were low. Only five of the twenty women confidently told us they could read and write. All women were bilingual in Spanish and Kaqchickel to some degree, but, from later reports, it was learned that some women had difficulty understanding lesson sections explained in Spanish. Almost all families derived their income from the husband's labor on the neighboring plantation. Monthly incomes varied and, while women had a difficult time giving an exact number, most reported that their husbands brought in about 35 quetzales a day for a normal day of agricultural labor. Oftentimes this was supplemented with artisan income; many women in San Martin create textiles. The average monthly income of 715 quetzales translates to about $92 per month or about $3 per day to provide for a family with an average size of 7 people.

None of the women interviewed had access to potable water. All receive their water from in-home faucets. The community tank was chlorinated sporadically and infrequently. Although only 45% of the families reported collecting rainwater, from our observations it seemed all homes had a rainwater collection unit, usually a large plastic container. Our question did not make this response option obvious so we believe rainwater collection was underreported. While most of the families use chlorine for washing and cleaning, none of them used it to purify their drinking water. From personal experience and published literature, there is a noticeable aversion to drinking chlorine in rural Guatemala (Nagata et al. 2011). All but one woman said she boiled her drinking water. Boiling times varied widely, from stopping as soon as the water came to a boil to stopping after 50 minutes (data not shown).

The community had a strong awareness of the poor quality of their water and the subsequent adverse health effects. They were very vocal about the need for a clean water project. This awareness was again reiterated in responses to the survey question about common household illnesses. The most commonly cited illnesses were diarrhea, vomiting, and stomachache, and many women specifically attributed these conditions to drinking contaminated water. One woman even claimed her young child had dysentery due to the community's water supply. Most families first turn to natural medicines or home cures and if these measures fail, they travel to the local health post or the larger in-town clinic or health center. The results of the family profiles for the first round of participants are summarized in Table 1.

**Methodology**

The twenty original participants were chosen with the help of community leaders on a need basis. A full list of COCODE members (community leaders), as well as their initial list of the twenty neediest families, was acquired in order to ensure no suspicious relations, i.e. if COCODE members were unfairly signing up their own relatives to be first in line to receive filters.

**Table 1: Demographic and water use characteristics of first round participants for WASH Community Education Program, San Martin, Guatemala, Summer 2012**

| | **Average (range) or N (%) (n=20)** |
|---|---|
| **Age** | 34.4 (23-57) |
| **Literate** | |
| Yes | 5 (25) |
| Somewhat | 7 (35) |
| **Preferred language** | |
| Kaqchickel | 15 (75) |
| Spanish | 4 (20) |
| Either Kaqchickel or Spanish | 1 (5) |
| **Number of children** | 4.7 (1-9) |
| **Husband's occupation** | |
| Agriculture | 18 (90) |
| Artisan | 1 (5) |
| Disabled | 1 (5) |
| **Monthly income in US dollars** | 92 (26-153) |
| **Access to potable water** | |
| No | 20 (100) |
| **Water source** (combination answers possible) | |
| Faucet | 20 (100*, 67+) |
| Rain | 9 (45, 30) |
| Buys bottled | 1 (5, 3) |
| **Boils water** | |
| Yes | 19(95) |
| **Uses chlorine** | |
| Yes but not in drinking water | 14 (70) |
| No | 6 (30) |
| **Most common household illnesses** (combination answers possible) | |
| Diarrhea | 15 (75, 42) |
| Vomiting | 6 (30, 17) |
| Stomachache | 3 (15, 8) |
| Cough | 3 (15, 8) |
| Cold | 2 (10, 5.5) |
| Headache | 2 (10, 5.5) |
| Fever | 1 (5, 4) |
| Infection | 1 (5, 4) |
| Family rarely sick | 3 (15, 8) |
| **First action in event of illness** (combination answers possible) | |
| Natural medicines | 12 (60, 39) |
| Health center or clinic | 10 (50, 32) |
| Small community health post | 6 (30, 20) |
| Pharmacy | 2 (10, 6) |
| Community health promoter | 1 (5, 3) |

The aim of the project was as an education and technology intervention, with the evaluation focusing on the success of the program's class component. Although there was no control group, multiple evaluation measures were employed to provide ongoing feedback about the progress of the course and the functioning of the filters, comparing results to the community or individuals at baseline. Prior to beginning the program, door to door visits were made with a translator to perform a basic family survey for each participant and her family. This survey inquired about family composition, education, income, language preferences, and basic water, sanitation, and health practices. Additionally, before and after each unit (hygiene and sanitation, nutrition, and the biosand filter), the participants were given a pre- and post-test by the teacher on key learning goals. Individual answers were recorded without identifiers. Each exam was graded and scored directly compared from the pre-tests to the corresponding post-tests. However, the open-ended questions proved difficult to compare with numerical scores. Thus, results from a few select questions were examined.

After the first and second units, a UVA-GI employee based in the country mediated structured interviews to participants without the presence of the teacher. The goal was to learn about participants' feelings about the class: what they liked and did not like, what was going well and what could be improved upon. For each question, answers were coded and frequencies tallied. Multiple responses by each participant were possible and common for all questions. This data was charted to better evaluate common themes. Additionally, the teacher provided a detailed monthly report about the progress of the classes, focusing on both goals achieved and problems encountered.

Finally, after filter installation, a third in-country UVA-GI employee was hired and trained to perform weekly filter checksfor each participant. These reports investigated filter cleanliness and flow rate and inquired about chlorine use (which is recommended after filtration) and whether or not the participants had any problems or questions. The evaluation scores received for the cleanliness of the filers was reflective of short notes describing the upkeep of the filter exit tube and the inner diffuser plate. However, often, a filter check could not be performed because the family was not home. In such cases, 2 points were subtracted from the date's percentage denominator for each unvisited filter. Cleanliness over time was graphed for both individual filters and for the group as a whole.

Preliminary water tests were taken during the last visit to the community, testing for the presence of total bacteria, total coliform, E. coli, and nitrate. In the process of this testing, each participant's home was visited and the tests were supplemented with detailed notes on the state of their filter, the room it was kept in, and its reported use. This information was used to supplement the data in the filter check reports. Table 2 provides a summary of all our evaluation measures and how they were analyzed. IRB approval was granted for this study under IRB-SBS #2012018100.

**Results**

*Pre- and Post-Tests*

The original intention of the pre- and post-tests was to directly compare pre-test scores to post-test scores. The reason that the below-mentioned percentages are not direct fractions of a group of 20 students is because of missing data due to participant absence or occasional additional responses given by the local health promoter, who sat in on the classes. The denominator ranges from 19 to 21 participants. Many pre-test responses were not necessarily incorrect, but when compared to their corresponding post-test responses, the change in answers made it evident that the women had retained new information from the curriculum. Four specific questions that give strong insight into the educational retention throughout the course were examined.

*Structured Interviews and Teacher's Class Reports*

Responses from structured interviews and supplemental notes from our teacher's monthly progress report showed recurring themes regarding participant perceptions of the program.

*Class content*

Overall, the participants were very satisfied with the themes of the course. A quote from the teacher, translated from her monthly report, gives strong insight into participant excitement about class content:

> *"Each participant is very happy to learn many things that she never imagined. They say that no other project has brought them such good themes, especially how to prevent illness. They imagined that we would only be talking about water so they are very happy because now they can better take care of their families."*

In the first structured interview on favorite lessons learned, the women named "bacteria/viruses/parasites" and "water usage" most frequently (ten mentions each). In the second structured interview, women cited a range of learning points about nutrition, including vitamins and minerals, produce, and childhood nutrition.

*Teaching Methods*

Participants commonly said they were happy with how the class was taught. There was very little negative feedback in thisarea. Many women described the class as "dynamic." In response to the question "How does your teacher teach the classes?" the number one response was that she gives clear responses (nine mentions). That she "teaches with a dynamic teaching style", "is patient", and "is punctual" were tied for second (six mentions). The class is taught bilingually, which was strongly appreciated by most women.

*Desire for Additional Themes/Classes*

The classes seemed to encourage many of the participants to want to learn about additional health topics. While only one participant clearly stated that she would have liked to learn less about a topic (hygiene), there were many suggestions offered up to either expand upon an existing class theme or to add additional themes. Proposed themes that did not already exist in our curriculum included: information on medicines, preparation of specific healthy foods, women's health, cancer, family planning, and sexually transmitted diseases. Women who participated in the classes also continued to meet on a regular basis to discuss the latest health topics.

*Knowledge retention.*

Interestingly, when asked "Is it easy for you to understand and pay attention in class?" after the first unit, 16 women responded "yes", two responded "yes but the children are distracting", and two responded "no due to difficulty understanding Spanish." When the same question was asked after the second unit of classes, only eight women responded yes for various reasons. Seven women responded "yes but they forget the material afterwards". Four women said no, either blaming their low level of education, their age, or their difficulty understanding Spanish. Notably, they did not fault the class for these problems but their own personal circumstances and background.

*Class Absence*

From the teacher reports, the biggest point of contention throughout the first round of classes was participant absence. There was controversy when one woman missed more than the allotted amount of three classes. A compromise was reached in which the woman had to complete an additional homework assignment. The teacher reported that the woman even exceeded the requirement by adding pictures and diagrams. However, overall class absence levels were low.

**Filter Check Reports and Water Examination Results**

The first week post-installation, each of the 22 filters installed in San Martin was reported to be clean, giving the group as a whole a 100% filter cleanliness rate. However, there was a significant drop just one week later. The community rate fell to 64%. This is possibly because the women were instructed not to use their HydrAid filter until 14 days post-installation. The manual explains that it takes about 14 days for the biolayer to form, a critical component in its water filtration process. It is possible that the women were little invested for these first two weeks in maintaining their filters since they knew they could not drink the water, or that they were still unfamiliar with their filters and did not yet understand the importance of keeping its contents clean.

During weeks four through ten, the community rate again rose and hovered between 90-95%. A critical event occurred during week nine when, during a community visit to take water samples, it was noted that the three problem filters had grown bacteria and total coliform in quantities too numerous to count. In addition, one of these filters grew an alarming amount of e. coli colonies (88 colonies in a 10mL water sample) in the output water. Samples were also taken of some well-kept filters with no associated complaints as well as samples of direct faucet water. Although one participant complained of gusanitos ("little worms") in the water level about the diffusor plate, her water showed very low levels of contamination. This participant generally took very good care of her filter and was the only participant who regularly chlorinated her water in adequate amounts. Input from in-country partners helped conclude that the commonly-reported gusanitos are a part of the untreated communal water supply, present in faucet water and/or stored rain water, and are unable to pass through the sand in the filter.

As a result of this sampling, the teacher and filter maintenance worker reinforced the importance of regular filter care and cleaning to the participants. As seen in Figure 1 the rates climbed steadily up and reached 100% after week 11. It is believed that this is largely due to efforts to increase filter cleaning and regular maintenance steps.

*Photo credit: Simone D. McCourtie/World Bank*

**Discussion**

Based on results from evaluation documents, the first round of classes have been considered as a success. The first round of participants gave very positive feedback on the program as a whole. They found the class themes to provide valuable knowledge and were pleasantly surprised to find the curriculum included much more than simply how to use their filter. In teacher reports and structured interviews the women commonly expressed that many of these concepts were new to them. It was often reported that participants appreciated how the knowledge on hygiene, sanitation, and nutrition could help them better take care of their families.

Praise was also received for how the classes were taught. Efforts to make the classes dynamic by adding activities and visuals proved beneficial. Although San Martin previously has had community health education (organized by the San Lucas Tolimán clinic), both the teacher and participants expressed that they had never been a part of a course like this one. The most recurrent complaints or concerns with the classes were difficulties with knowledge retention and difficulties understanding sections of the class which were taught in Spanish. However, results from pre- and post-tests still show strong understanding and short-term knowledge retention in key areas. Overall, the women felt the program was very beneficial to the community, primarily citing the necessity of the filters. Many women from the first round of classes have expressed a desire to continue their education with supplementary classes on new health themes.

The biggest concern, expressed by only a few women, was with filter malfunctions. UVa students and faculty are working closely with in-country partners and filtration experts to understand the cause of these problems and to improve the filtration system to ensure all filtered water is up to drinking standards.

Based on the analysis of the documented results, it has been found that the multi-marker evaluatory system would benefit from some changes and additions. The pre- and post-tests have been made less open-ended and therefore easier to analyze. This should improve the assessment of knowledge retention among participants. It also would be worthwhile to administer a comprehensive post-test several weeks after completion of the course to test long-term knowledge retention for the first round of participants.

To increase the informative power of the project assessment, the study authors are currently working with the teacher and in-country director to come up with a few simple questions to measure health behavior change, an area of evaluation that is lacking. While it is possible to measure behavior change with regard to filter use and maintenance through regular filter check reports, there is inadequate measurement of behavior change in the realm of the first two units: (i) hygiene and sanitation, and (ii) nutrition.

Furthermore, it is hoped to bolster the quantitative assessment by performing more biological water testing. While this report has focused on the process and outcome of the classes (and has primarily focused on filters through the spectrum of participant filter maintenance, which is more reflective of the classes than the filters themselves), it is equally important to ensure the filters are functioning up to standards and producing potable water for all households.

Geographic and language barriers have been one of the biggest limitations to this research. UVa students are unable to easily implement changes to the evaluation process and must rely on in-country partners to collect the majority of this information and report back in a clear and timely manner. It is thus necessary to keep personnel constant for each evaluation form to reduce inconsistency in subjective measures (i.e. the filter check reports are always performed by the same man). Fortunately, the in-country partners have proven to be very reliable and competent. They have the added advantage of ability to speak the local indigenous language, Kaqchickel. It is undeniable that the success of this project would be impossible without the study's Guatemalan partners.

The second major limitation to this research has been the lack of power both in sample size and time. As this is only an evaluation of the first round of classes, assumptions cannot be drawn about the long-term effects of this program on the community in its entirety. Since less than a year has passed since the initiation of the course to the writing of this evaluation, and participants have only been using their filters for a few months, it would be premature to make inferences about the program's effect on the health of the community. Benefits in education, empowerment, and cross-cultural partnerships can be claimed; however, direct health effects such as a decrease in diarrheal incidence and improvement in child health are goals that will be better measured in the coming months and years.

The program is among few of its kind in the published literature which takes such a comprehensive approach to the water needs of a community. It combined both an extensive literature and geographic review, as well as gauging the interest of the community to participate. Community leaders were extensively involved in project planning to secure approval and come to an understanding of what the mutual commitment would entail. The curriculum was tailored to the population and local Guatemalans were hired to teach the course and monitor the filters. Believing strongly in the importance of the educational component, filters were not distributed until the women had proven strong participatory investment in the program. Finally, once the filters were installed, regular checks on their maintenance and use were performed. Many projects which attempt to deal with the water crisis only accomplish a segment of the scope of this project.

Moving forward, another grant from UVa's Jefferson Public Citizen program has been acquired which will provide with enough funds to run the project to completion. The study will continue to be developed and refined as well as expanded to allow more community members to participate in the course. This will add power to the findings and increase ability to measure changes over time on a larger scale. It is hoped that the results will ultimately provide insight into the program's direct effect on community well-being. The ultimate goal of all of these qualitative and quantitative assessments is to tailor the program to maximize its benefits to the community of San

**Table 2 – Summary of Program Evaluation Measures for WASH Community Education Program, San Martin, Guatemala, 2012**

| Document | Frequency | Purpose | Analysis |
|---|---|---|---|
| **Family Profiles** | 1 for each participant's family | To provide a basic family background | Summarized (reference for community demographics and for individual participants) |
| **Teacher's Class Reports** | 1 each month | To give feedback on problems encountered, solutions undertaken, goals accomplished, and general commentary | Summarized (reflect progress of the course) |
| **Attendance Record** | 1 each month | To record class attendance for each participant | Tallied |
| **Teacher's Work Log** | 1 each month | To log the durations of specific activities, costs of materials and transport | Tallied, summarized (review distribution of time and money spent) |
| **Filter Check Reports** | Once a week for first months 1-3, biweekly for months 3-6, once a month for months 6-12, once at month 18 | To check family upkeep of the filters and inquire about any problems | Summarized and coded (review trends in upkeep, special focus on problem filters) |
| **Pre- and Post-Tests** | Before and after each of the three units | To measure knowledge retention | Graded, comparing pre- to post-tests with an emphasis on specific questions |
| **Structured Interviews** | After the first two units | To receive participant feedback on the classes | Summarized and coded (reflect participants' overall feelings about the program) |
| **Water Examination Results** | Once for the first group (follow up to come) | To assess the bacterial and nitrate content of the filtered water | Summarized (not enough test were performed for a statistical analysis) |

| Question | Pre-Test | Post-Test | Commentary |
|---|---|---|---|
| **If water is clear, do we still need to purify it?** | 68% correct | 100% correct | In the pre-test, four women directly responded "no" – that they believed clear water did not need to be purified. Two of the women specified that all faucet water needed to be purified but clear rainwater did not. In the post-test, all women responded that clear water did not necessarily equate to clean water and that all water should be purified. This is one of the first learning points in our curriculum. |
| **What can cause diarrhea?** | 100% correct | 100% correct | This example proves the difficulty of scoring an open-ended question. In the pretest, the answers were not incorrect but they were notably different from the post-test answers. A typical answer from the pre-test is "dirty water, trash, and mud." In fact, diarrhea-causing contamination could be found just about anywhere. So this was a fault of question wording. However, in the post-test, 86% of the responses included some mention of bacteria, parasites, amoebas, or worms, as opposed to 0% in the pre-test. 'Microbes' is a major learning point in the hygiene and sanitation unit of the course. |
| **Name three vitamins that the body needs to be healthy** | 10% correct | 85% correct | The two correct responses in the pre-test (10%) were participants who listed vitamins A, B, and C. The majority of the other participants listed specific food or food groups. For example: "herbs", "carrots", "beans", and "incaparina", a popular high-protein powdered drink mix. In the post-test, 17 out of the 20 respondents (85%) correctly named three vitamins. The three that were marked incorrect only named two vitamins (two respondents) or one vitamin (one respondent). This increase in knowledge about vitamins and minerals is paralleled in the next question, "Name two minerals that the body needs to be healthy," and in supplemental evaluation material in which participants expressed that they were not aware of the concepts of vitamins and minerals in their food. |
| **What are three important things you should remember about maintaining your filter after it has been installed?** | 19% correct | 100% correct | It is unrealistic to expect the participants had much knowledge about HydrAid filters prior to participating in our program. The intent of this question was to assess whether they could understand and remember necessary filter care after the unit. The post-test responses to this question were very reassuring. Each participant listed at least three critical steps of care. Examples include: "do not move your filter", "do not allow children to play near or with the filter", "clean the filter diffuser plate", and "do not chlorinate the water going into the filter". |

Martin and, furthermore, to create a project model which can be extended and specially tailored to other communities in need of potable water.

**Addendum**

In the summer of 2013, a team of four UVa students traveled to San Lucas Tolimán to continue research and evaluations. Their interactions translated to over 150 hours of community time. Evaluations included: environmental surveys of each filter set up, biological testing for total coliform and E. coli, pre- and post-tests, focus groups with some of the participating women, interviews with families, community leaders, local health professionals, and in-country project leadership. This new group of students incorporated the suggestions derived from this study, including revision of focus group and pre- and post-test questions and addition of questions designed to discover more information about relevant changes in health-related behavior within families. As of October 2013, the third and final group of San Lucas Tolimán residents had begun classes. The program was expedited after the first class, per community request, increasing the number of participants in each round of classes by staggering two groups within a normal class period. Overall, a complete analysis of their evaluations asserted continued community consensus that the project was a useful, desired, and successful collaboration.

*Photo credit: Ben Beiske*

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